World's Oldest Hematite (3.46Ga) from Marble Bar, Western Australia

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The Towers Formation (3.46Ga), Warrawoona Group, Western Australia hosts the oldest major jasper/chert sequence in the world: a100m thick unit, dipping nearly vertically, continuous for over 20km and inter-bedded with pillow lavas and tuffs. Hematite, the ferric iron mineral responsible for jasper's distinctive red color, could have formed by either 1) the modern oxidation of ferrous iron minerals (e.g. siderite) or 2) primary (and/or early diagenetic) Fe^{2+} oxidation in 3.46Ga oceans. Red jasper in drill core recovered from ~100-150m underground correlates stratigraphically with jasper found at the surface, indicating the hematite formed from primary mineralization, not modern oxidation.

Primary hematite could have formed through three Fe^{2+} oxidation mechanisms: 1) photochemical reaction in surface water, 2) iron oxidizing bacteria in the photic zone, or 3) mixing with O_2-rich surface or bottom water. Discerning between these possibilities is integral to understanding the chemical evolution of the early earth and earth like planets. To that end, the first ABDP hole retrieved a continuous drill core of fresh rocks (modern weathering free) from the Towers Formation in the summer of 2003.

Approximately 110 drill core samples, including pillow lava, tuff and chert, have been investigated by employing microscopic (SEM, TEM, X-ray chemical, and petrographic thin section), chemical (GC, ICP-MS) and isotopic analyses. Special effort was made to identify: (a) the systematic morphology and grain-size distribution of hematite crystals (<1 – 50 μm) and (b) hydrothermal signatures (e.g., REE anomalies; heavy metal ratios and distribution) in the jasper/chert and associated igneous rocks. Our results suggest that most of the fine-grained hematite crystals in the Towers Formation formed by rapid mixing of Fe^{2+}-rich hydrothermal solutions with O_2-rich bottom waters. Furthermore, the presence of an oxygenated deep sea implies a fully oxygenated atmosphere at 3.46Ga.